Building Research Establishment Digest

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Prediction of traffic noise: part 1

This digest describes prediction methods for a wider range of conditions than Digest 153 which was concerned with motorway noise and which is now withdrawn.

This digest is published in two parts. Part 1 deals with the prediction procedures; Part 2 (published February 1976) illustrates some of the procedures by a worked example and gives information on barrier design, definitive formulae on which the charts are based and information on traffic speeds to be used in the context of the regulations.

The L_{10} noise index has come into general use for the assessment of traffic noise. The L_{10} (18-hour average) index has been adopted by Government for planning and to determine entitlement of dwellings to sound insulation treatment. This digest sets out the recommended method for predicting L_{10} (1 hour) and L_{10} (18 hour) noise levels due to road traffic at points up to 300 m from the road. It also describes how to allow for the effects of obstructions and roadside barriers.

Space does not permit the charts to be reproduced here at a size that can be used for accurate prediction; much-reduced illustrations are included merely as an aid to comprehension of the techniques. The charts are reproduced full-size in 'Predicting road traffic noise' [1].

Introduction

This digest is based on the Department of the Environment's publication 'Calculation of road traffic noise'[2] which should be consulted for a more detailed exposition than is given here. Prediction is for typically adverse noise conditions ignoring non-permanent site features which might influence received noise levels.

The designation L_{10} denotes the level in dB(A) which is exceeded for one-tenth of any specified hour. The L_{10} (18-hour) level is used in regulations[3] and in certain planning considerations; it is the arithmetic mean of the 18 separate one-hourly values of L_{10} covering the period 06.00 to 24.00 hours, on a normal working-day.

Predictions are made in a series of steps, each involving the use of a formula which in most cases is also presented graphically. In many situations the use of the charts will give acceptable accuracy, even though the errors in chart reproduction and reading may result in errors in the final prediction of up to 1 dB(A). When high accuracy is required the calculation should be based on the definitive formulae given in Part 2 of the digest. Each step in the calculation should be accurate to 0·1 dB(A). The overall result should be rounded off to the nearest whole number, 0·5 dB(A) being rounded up.

Outline of procedure

To predict the noise at the reception point, first predict the noise at 10 m away from the nearside road edge using the traffic data: flow, speed and percentage of heavy vehicles, allowing for the road gradient and surface where appropriate.

Then apply a series of corrections to this 10 m noise level to allow for propagation—distance of the reception point from the road, nature of the intervening ground and screening—and for complexities such as non uniformity of the road, partial screening, angle of view from the reception point, multiple sources and reflection effects, all appropriate to the particular situation.

The limits of the prediction method are indicated by the scales on the charts. Extrapolation is likely to cause errors.

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Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

The procedure

In this section, the prediction procedure is described simply in a series of steps. Where fuller guidance on a particular input might be useful, it is included in the footnote below the procedure.

1 Prediction of 10 m noise level

From the traffic flow[a] determine a noise level 10 m from the road corresponding to no heavy vehicles, a mean speed of 75 km/h, zero gradient and a conventional road surface, see Fig 1 [b]

Apply a correction to take into account speed [c] and percentage of heavy vehicles [d], see Fig 2
Apply a correction for road gradient [e] of
0·3 G when actual mean speed is used, or
0.2 G when using design speed of road,
where G is the percentage gradient.

Apply the third correction, for road surface, only if road is concrete with 5 mm deep random grooving. The correction is (4—0.03 p) where p is the percentage of heavy vehicles.

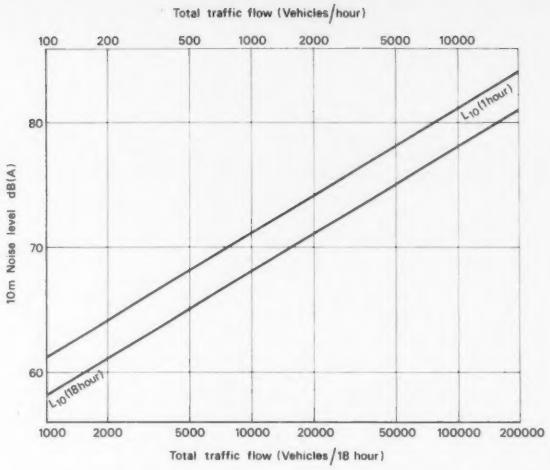

Fig 1 10 m noise level, L_{10} (1 hour) or L_{10} (18 hour) (V = 75 km/h; p = 0; G = 0)

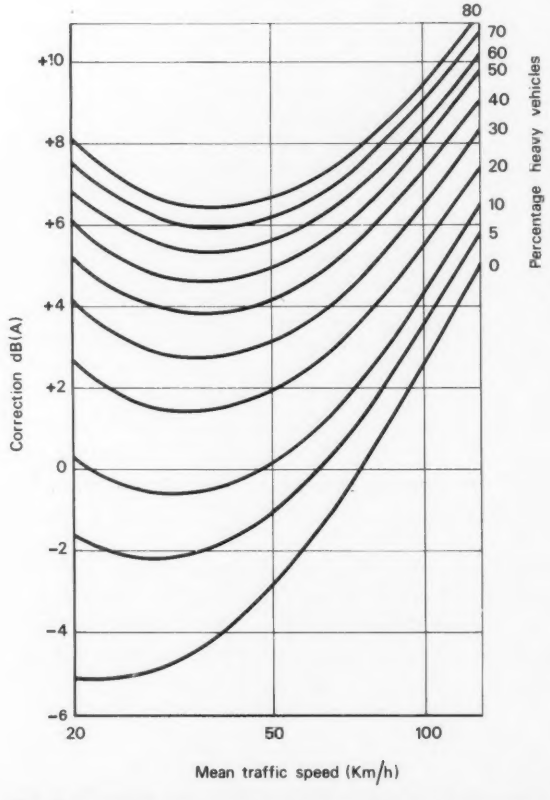

Fig 2 Correction for mean traffic speed, V, and percentage heavy vehicles, p

(a) Normally the flow in both directions is aggregated for flow and heavy vehicles. In the special case of dual carriageways being separated by more than 5 m or if their outer edges differ in height by more than 1 m, each carriageway should be treated as a separate road and the resulting levels at the reception point evaluated and then combined as described in Section 9.
(b) If L_{10} (1 hour) is required, enter hourly flow q veh/h into upper flow scale on Fig 1 and use the upper chart line to determine the noise level. For L_{10} (18 hour) enter flow Q, veh/18 h day into the lower flow scale on Fig 1 and use the lower chart line.
(c) The speed is the mean speed of all the vehicles in the flow.
(d) Heavy vehicles are defined as having an unladen weight exceeding 1525 kg (30 cwt approx).
(e) Where it is necessary to treat a dual carriageway as separate roads (under Note a) the gradient correction is applied only for the upward flow.

2 Open ground propagation—flat situations

Simple flat ground situations are not common. Only rarely will there be an unobstructed view of a straight, level and uniform road, where the intervening ground is uniform and flat and at the same level as the road. Nevertheless, procedures must be specified for idealised situations such as this as these are required in the treatment of more complex practical situations.

Figures 3 and 4 give the corrections to be applied to the 10 m noise level for propagation over hard intervening ground and grassland. The corrections take into account distance from the road edge [f] and height above ground of the reception point. The hard ground correction from Fig 3 is used for the distance correction when screening is involved, see Section 4. The grassland correction, from Fig 4, applies to all other non-hard ground surfaces [g].

3 Open ground propagation—sloping or undulating ground

To determine the distance correction, the contours should be rotated about the source position S [f], so that the base line of the contours passes through a point situated h′ vertically below the reception point, where h′ = 2 x (the average height of the propagation path above the intervening ground, source to reception point) minus 0·5m. If the terrain is such that the reception point is screened from the source, the treatment given in Section 5 applies instead.

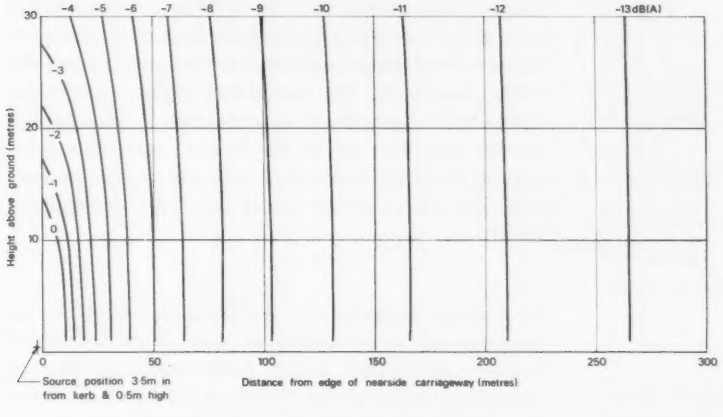

Fig 3 Propagation over hard ground: correction in dB(A) as a function of horizontal distance from edge of nearside carriageway (d) and height above ground (h)

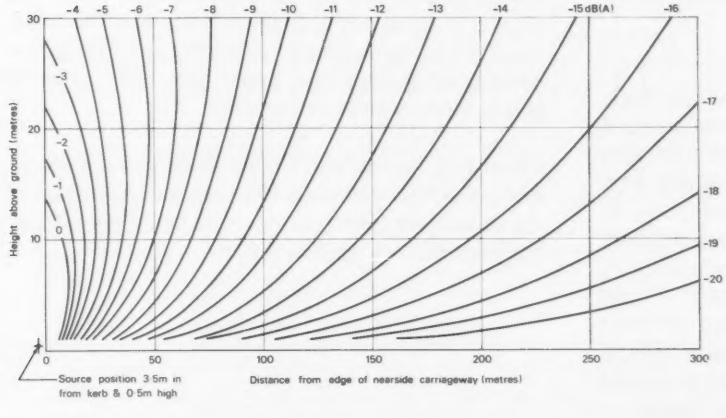

Fig 4 Propagation over grassland: correction in dB(A) as a function of horizontal distance from edge of nearside carriageway (d) and height above ground (h)

(f) Throughout the prediction method, the line of the source of traffic noise is taken to be 0·5 m high and 3·5 m in from the nearside edge of the road. If it is necessary to treat the different carriageways of a dual carriageway road as separate roads (note a) in the evaluation of the remote carriageway, the zero distance point on Figs 3 or 4 should be located at 7 m in from the far edge of that carriageway. For the near carriageway in such cases the zero distance point is located at the near edge of that carriageway, as for normal roads.

(g) In cases where the intervening ground is a mixture of hard ground and grassland, the correction for the type of ground which predominates applies.

4 Screening by very long simple barriers

Again this is an idealised situation corresponding to the open flat ground situation described in Section 2, but with an imperforate uniform barrier of constant height and distance from the road edge, long enough to obscure practically 180° of the view of the road.

The correction for screening to be applied to the noise level at the reception point, calculated as in Section 2 using the hard ground propagation correction of Fig 3, is determined from Fig 5. The correction is read from the curve at the appropriate value of the path difference (a + b − c)[h], see inset sketch in Fig 5.

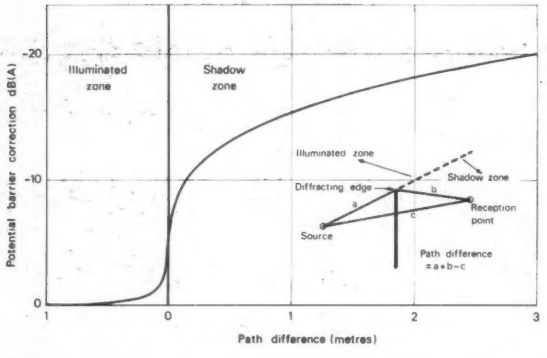

Fig 5 Potential barrier correction (very long barrier) as a function of path difference

An alternative to Fig 5 for the determination of the screening correction and one which does not need the calculation of path difference, is provided by the nomogram, Fig 6.

The nomogram is in two parts. The upper part deals with situations where the reception point is in the geometrical shadow of the barrier and the lower part corresponds to the 'illuminated zone' of Fig 5[h]. To evaluate the screening correction using Fig 6, determine a, b and h in metres from a scale drawing, see inset sketches in both parts of the nomogram[f]. Enter the horizontal scale on the left of the nomogram at (a + b) metres, the slant distance between the source and receiver. Draw a vertical line from this point on the horizontal scale to a point corresponding to the effective barrier height, h, using the height scale provided by the sloping lines.

From this point draw a horizontal line into the right-hand side of the nomogram. Enter the horizontal scale on the right-hand side of the nomogram at

$$\left(\frac{a}{a + b} \times 100\right)$$

and draw a vertical line from this point. The intersection point of this vertical with the horizontal line from the left-hand side of the nomogram is used to read off the potential barrier correction from the curves in the right-hand side of the nomogram, using interpolation if necessary.

5 Screening by low barriers, crash barriers, buildings and earthmounds

In some cases the correction for screening by low barriers may be less than the difference between the hard ground and soft ground distance corrections. In cases where the propagation is over soft ground the noise levels at the reception point should be evaluated for grassland, as in Section 2, ignoring the barrier, and also as in Section 4, using the hard ground distance correction and the barrier correction. The result which yields the lower noise level should be used.

As a single exception for the need for barriers to be imperforate, a conventional low crash barrier of double corrugated beam construction, with the mounting height of the centre of the beam no more than 610 mm above road level, should be treated as a solid imperforate barrier whose height above the ground is equal to the width of the beam. The treatment is then as in Section 4 and the remarks on low barriers in this section apply. All other types of safety fence should be ignored.

When buildings or earth mounds screen the reception point from the road, the height and position of the equivalent simple barrier may be determined by the method indicated in Fig 7.

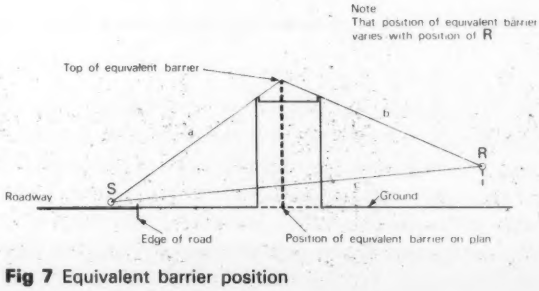

Fig 7 Equivalent barrier position

(h) The 'illuminated zone' part of Fig 5 is used to evaluate the small screening correction for reception points which can just see the source over the top of the barrier.

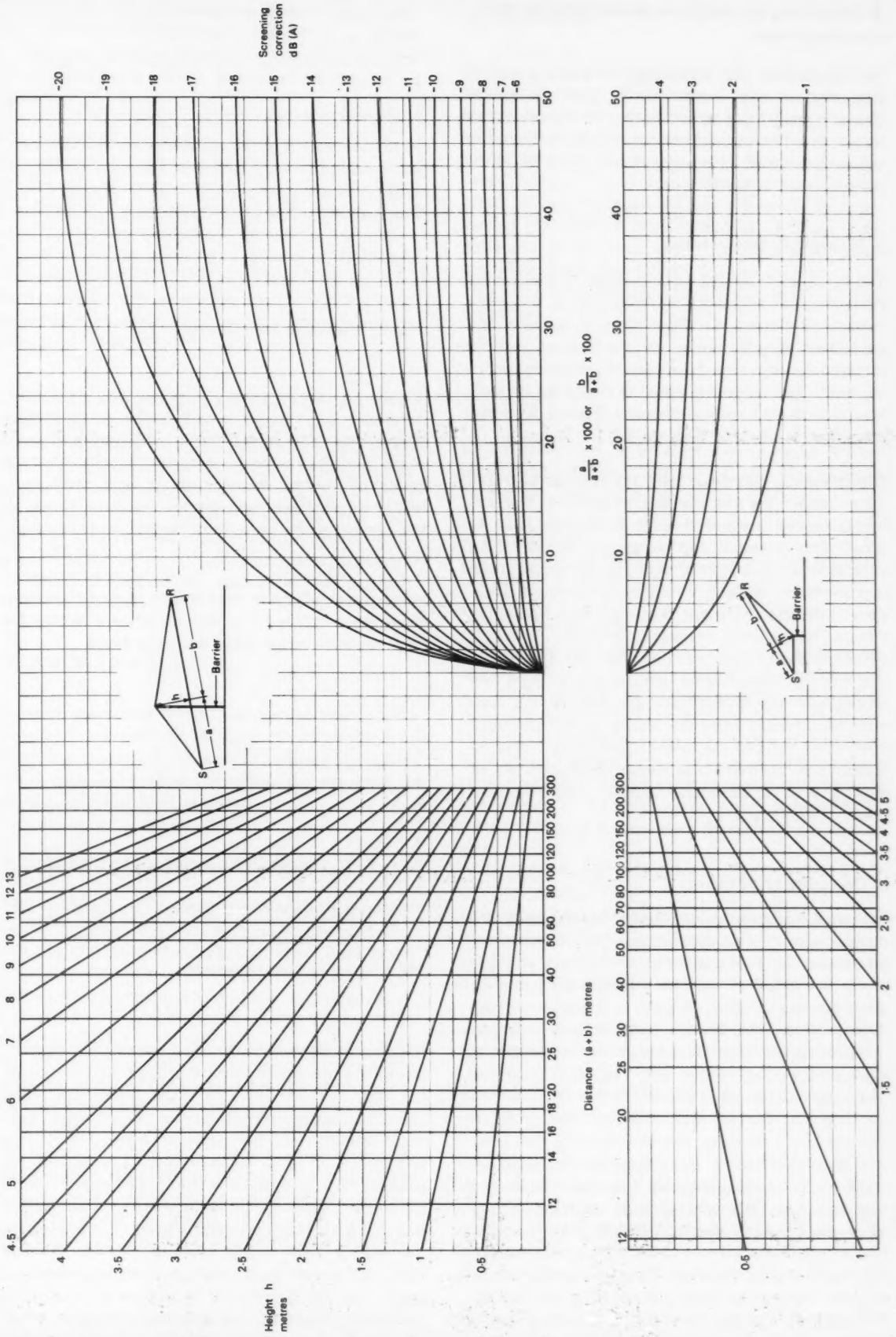

Fig 6 Nomogram for approximate potential barrier correction

6 Screening by roads on embankments and elevated roads

The correction for screening in these cases is evaluated in the same way as that for simple barriers using Fig 5 or 6. The top of the equivalent barrier will be the shoulder of the embankment or the outer edge of the elevated deck or the top of the parapet wall if this is solid.

7 Screening by cuttings

The screening correction for cuttings is determined from the path difference, as in Section 4, using the method indicated in Fig 7 to determine the equivalent simple barrier. In the special case of retained cuttings with near-vertical reflecting retaining walls, the screening effect is degraded by multiple reflections between the cutting walls. A further correction is given in Section 13.

The foregoing has dealt with the prediction of the 10 m noise level and the determination of the corrections which are added to the 10 m noise level, to allow for distance and screening in the rare situations where both the road and the propagation conditions are uniform throughout the whole 180° view of the road from the reception point. Reflection effects have been ignored. In most practical situations the configuration will be more complex in that the road may not be uniform and straight, the propagation conditions from one part of the road may be different from the propagation conditions from other parts of the road and reflections may influence the received noise level. The procedures for dealing with those more complex situations are given in Section 8.

8 Complex situations

In many cases the angle of view of the road from the reception point includes a range of different configurations, for example, bends in the road, changes in the elevation of the road, partial screening by short barriers or other changes in propagation conditions. In such cases the field of view from the reception point must be divided into a number of segments so that within each segment the conditions are uniform and simple. With a straight road for example, part of the angle of view may be screened by a building, another segment may have soft ground between the road and the reception point and for a third segment the road may be in a cutting. The received noise contribution is calculated for each segment as described above by first assuming that the simple configuration obtaining for the segment applies to the whole 180° angle of view and then by adding a correction for the actual angle of that segment using Fig 8. In this, distance is measured perpendicularly from the extension of the line of the road within the segment.

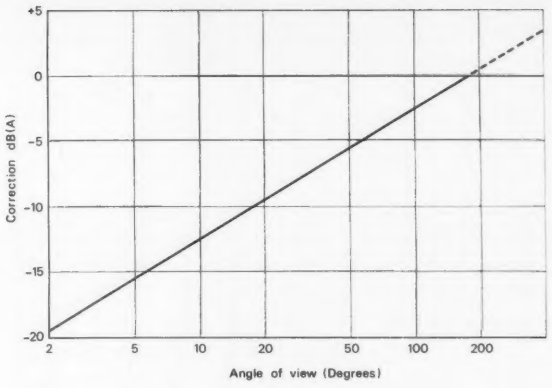

Fig 8 Correction for angle of view

Similarly, for screening calculations the path difference is evaluated using a section perpendicular to the extension of the line of the barrier. Curved roads are dealt with by approximating them to a series of shorter sections of straight road each within its segment (but see below for guidance on the choice of the number of segments necessary).

Having evaluated the contribution of each segment, these are combined successively in pairs to give the total received noise level by using Fig 9.

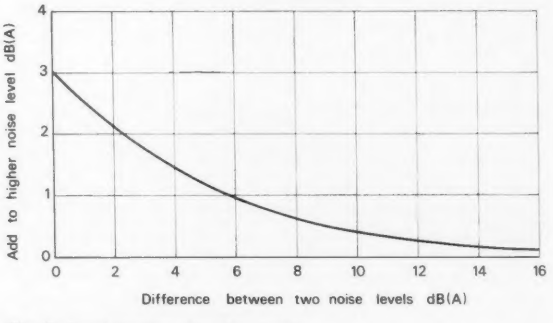

Fig 9 Combination of noise levels

In some cases, where the road bends away from or round the reception point, the angle subtended by the road will not be 180°. The procedure given above still applies but the sum of the individual segment angles will be different from 180°. The application of this segment principle allows for predictions in all situations within the limits of traffic parameters indicated by the scales in the charts but in some particularly complex situations the need for the configuration within each segment to be uniform and simple could lead to a large number of segments. The number of segments required is a matter of judgment. For practical purposes, small changes in propagation conditions within a segment are acceptable. As a guide, the extremes of the

propagation conditions within a segment should not correspond to uncertainties of more than ±1 dB(A) in the noise levels received from that segment. The mean contribution from the segment should be used.

The procedures given so far cover the evaluation of the corrections to be added to the 10 m noise level, in situations where the configuration can be divided into segments, each segment covering a simple and uniform source and propagation condition. Remaining topics are the procedures for dealing with more than one road, road junctions, screening by more than one barrier, screening by rows of buildings with gaps between, noise levels down side roads and the effects of reflection.

9 Multiple sources and road junctions

The method used for combining the noise levels from the segments of a complex configuration applies to the combination of the noise levels from two or more roads and Fig 9 is used. The contributions are calculated using the appropriate traffic data and propagation conditions. For road junctions any speed change in the vicinity of the junction should be ignored.

10 Multiple barriers

In situations where more than one barrier screens the reception point from the road, the screening corrections for each of the barriers should be determined separately. Only the correction resulting in the lowest noise level is used.

11 Screening by a row of buildings

For a reception point partially screened by a row of houses or other buildings parallel to the road and with gaps between the buildings, strict application of the segment principle will often lead to a large number of segments and tedious calculations. In such cases a simplified procedure may be used. This is based on using only two segments, one to cover the contributions through the gaps between the buildings and the other to cover the contribution from the parts of the road screened by the buildings.

The angle of the single segment covering the gaps between the buildings is 180° x Z and the angle of the other segment is 180° x (1 − Z), where $Z = \frac{\overline{R}}{\overline{R} + b}$, $\overline{R}$ is the mean gap between the buildings and b is the mean length of the buildings.

For each segment apply corrections appropriate to the propagation conditions.

12 Side roads

Noise levels down side roads from main roads are calculated using the segment principle. In this special case, the contributions of the segments within which the main road is screened from the reception point by housing in the side road are ignored. In most cases this means that the only segment to be considered is that defined by the aperture of the junction of the side road with the main road and the distance of the reception point down the side road. Propagation down the side road should be calculated using the hard ground distance correction.

13 Reflections

All the procedures given above have ignored the influences of reflections and in many situations further corrections need to be applied as follows:

(*i*) *Façade effect*
For reception positions 1 m from a building façade a correction of +2·5 dB(A) is required.

(*ii*) *Façade opposite*
Where there is a substantial reflecting surface on the far side of the traffic flow a further correction of +1 dB(A) applies. In this context the substantial reflecting surface could be a wall, a noise barrier or buildings lining the road on the far side of the traffic flow. The +1 dB(A) correction applies if the percentage opening due to gaps in the reflecting surface on the far side of the traffic flow does not exceed 50 per cent. If gaps predominate then this correction is zero.

(*iii*) *Side roads*
At all positions between façades down a side road, whether 1 m from a façade or not, a correction of +2·5 dB(A) is required. This correction is not in addition to that under (*i*) above.

Correction for the opposite façade applies to a side road only when there is a substantial reflecting surface along the main road opposite the end of the side road and within the angle of view of the main road from the reception point.

(*iv*) *Retained cutting*
For retained cuttings, the degradation of the screening correction due to reflections depends upon both the depth of the cutting and the angle to the vertical of the retaining walls. If the walls are vertical, an additional correction to the prediction (having already taken screening into account) of D dB(A) is required, where D is the depth of the cutting in metres. If the walls of the cutting slope back, the correction is (F × D) dB(A), where F is given by Fig 10.

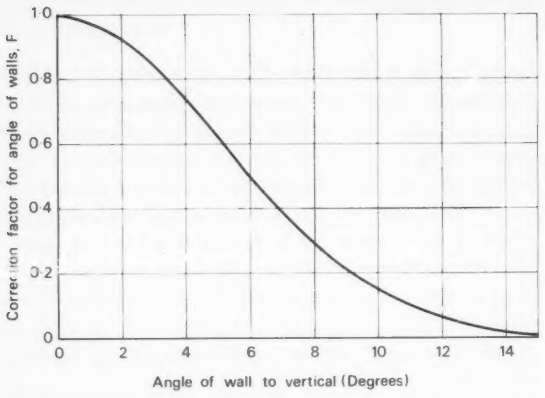

Fig 10 Correction factor, F, for reflection effect of hard-walled cuttings (overall correction for degradation of screening by retained cutting = F × D dB(A))

This correction includes that necessary for opposite façade, (*iii*) above, and therefore the separate +1 dB(A) for the far retaining wall does not apply in the case of retained cuttings.

The above procedures will calculate traffic noise in the vast majority of situations. They apply to typical traffic flows. However, for unusual traffic characteristics, eg severe congestion, for traffic flows outside the ranges covered by the scales of Fig 1 and for distances outside the ranges in Figs 3 and 4, use of the procedures may lead to errors and a measurement may be necessary. Specifications of the measuring equipment to be used, when necessary, in determining entitlement to sound insulation treatment are given in the regulations[3].

References

1 Predicting road traffic noise; 1976; HMSO.
2 Calculation of road traffic noise; 1975; HMSO; £1·70
3 Noise insulation regulations; 1975; HMSO.

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